Space Weather Technical Forecast

Issued on Tuesday, 30 July 2024 at 13:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: CME arrivals expected, most likely day 2 (31 Jul), with G1-G2 Minor to Moderate storms and a chance of G3 Strong Storms. Ongoing M-class and X-class flare risk.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High with at least eight M-class flares observed, including an M8.7 from AR3762 in the northwest at 29/1255 UTC and an M6.4 from AR3672 in the southeast at 29/1957 UTC. There are eleven sunspot regions on the disc, with a number of these containing delta spots. Slow growth has been observed in AR3768 in the southwest, with increasing areal extent, while a cluster of four sunspots persists just west of centre disc, with complex interactions between them due to their proximity. AR3770 in the north-centre disc also maintains a strong, albeit small delta spot to its north, while new region AR3772 in the southeast is showing apparent growth and increasing complexity as it rotates into view. Magnetic looping on the centre east-limb in SDO imagery also suggests the potential for a further oncoming strong region.

A number of CMEs were observed, however only the M8.7 flare has currently been assessed with the potential for Earth-directed components. This likely giving a glancing arrival on 01 Jul.

Solar Wind / Geomagnetic Activity: A CME arrived at L1 at 29/2320 UTC. Solar winds speeds, as measured by ACE at L1, increased from background, below 350 km/s to 450-500 km/s with the arrival. Density was initially below average, but rose above average, also with the arrival. Interplanetary Magnetic Field, Bt, rose from weak to be Moderate to Strong from 29/2340 UTC at 14-19nT, but eased after 30/0500 UTC to be mainly Moderate at 9-11nT. The north-south component, Bz, rose Moderately positive with the arrival, peaking 13nT at 30/0113 UTC with the arrival, but then switched to negative with minimum -12nT at 30/0209 UTC. An erratic weakening trend was then observed but with a general magnetic cloud type rotation from, 30/0530 UTC from negative to positive values. Geomagnetic activity was Quiet to Unsettled (Kp1-3) at first, but increased to Active to G1 Minor Storm with the CME arrival (Kp4-5), with G1 observed 30/0300-0600 UTC.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 is at background. High energy electron flux (greater than 2MeV) observed at GOES16 was at Moderate, peaking 938 pfu at 29/1730 UTC, but declined to background after the CME arrival. The 24-hour fluence was below the Active threshold with 2.62e7 integrated pfu observed at 30/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High activity is expected with further M-class flares expected and chance of isolated X-class flares.

Solar Wind /Geomagnetic Activity: A number of CMEs have the potential to arrival through the period. The CMEs from the M9.9 early on 28 Jul, and then the M2.6 and long period M1.7 later on 28 Jul are then expected to arrive either late day 1 or most likely early on day 2 (30-31 Jul), likely combining into a single arrival. A further glancing CME arrival is then likely on day 3-4 (01-02 Aug) from the M8.7 flare on 29 Jul. No fast wind enhancements are expected, with CME

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arrivals expected to dominate, bringing spells of slightly elevated to elevated winds, along with periods of Active to G1-G2 Minor to Moderate Storms. There is a chance of G3 intervals, mainly day 2 (31 Jul)

Energetic Particles / Solar Radiation: High energy proton flux is currently at background. Should any notable flares occur there is a likelihood of this increasing above background, with a chance of exceeding the S1/Minor Storm threshold. This is due to the increasingly geoeffective location of the sunspot regions on the disc. The high energy electron flux is forecast to be mostly at background levels. The associated 24-hour fluence is expected to remain below the Active threshold (1e8 integrated pfu).

Figure 1a. Solar Analysis Valid: ACE Solar wind (from SWPC) showing CME arrival

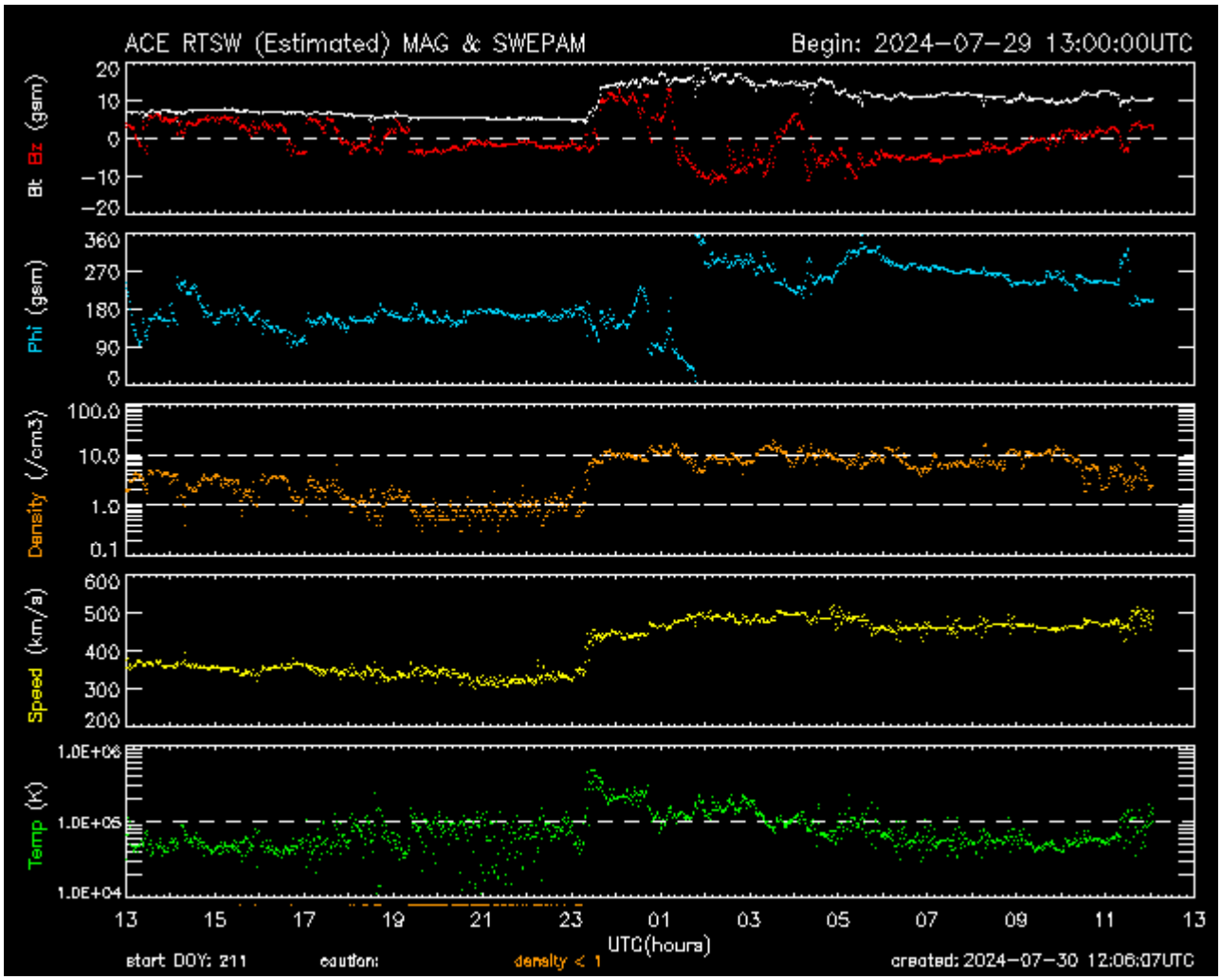

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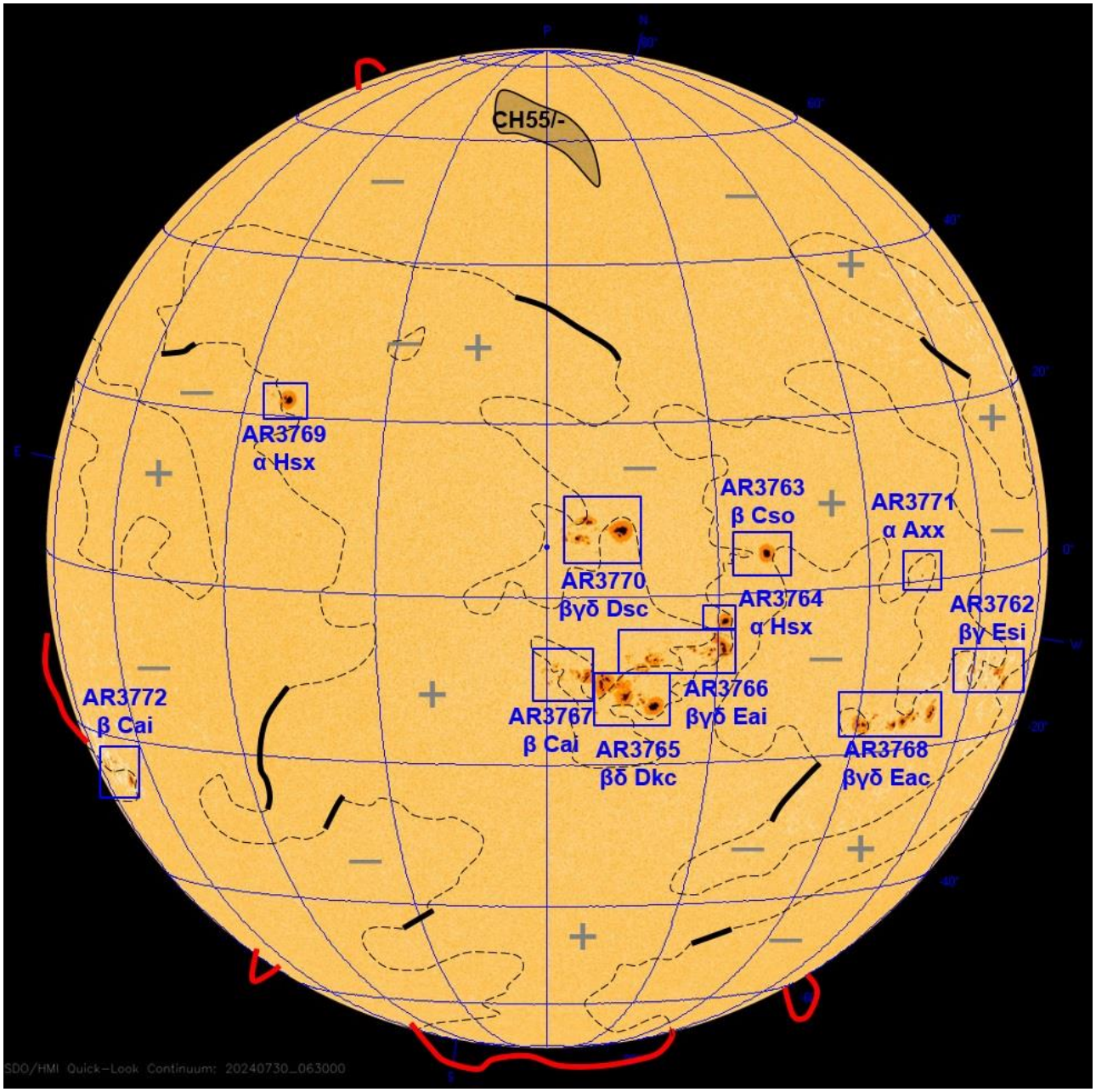
Figure 1b. Solar Analysis Valid 360/0800 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Current CME influence from the arrival overnight is expected to ease, however there are further Earth-directed CMEs that are expected to arrive through this period.

The first is a halo CME from the M9.9 from AR3766 on 28/0200 UTC, but likely mainly shock with limited material. The second is a partial halo from the combination of the M2.6 at 28/1250UTC from AR3762 and the long duration M1.7 at 28/1422 UTC from AR3768, off the southwest disc. This second CME is faster than the first, with both likely combining to give a single arrival early on day 2 (31 Jul). Timings are low confidence however, as both CMEs were non-trivial to assess due to contamination from other CME's occurring off the Earth-Sun line, and some poor imagery quality.

A further CME arrival is then possible on day 3-4 (01-02 Aug), from the M8.7 flare at 29/1255 UTC from AR3762 and the dimming that occurred to the north of the region. This is low confidence, however with a glancing impact most likely. Furthermore, due to the number of coincident CMEs, including those off the Earth-Sun line, analysis has been more difficult than usual. Consequently further weaker arrivals also cannot be ruled out through the period.

No fast wind enhancements are expected, with CME arrivals expected to dominate. These will bring periods of Active to G1-G2 Minor to Moderate Storms. There is a chance of G3 intervals, mainly day 2 (31 Jul).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	Yes	70	70	50	20
Strong	G3	No	15	25	10	5
Severe	G4	No	5	5	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
28/0808	Asymmetric Full	M9.9 AR3764	03W 04S	598 km/s	31/0300 -6/+12 hrs	Complex analysis Likely combined arrival with below
28/1838	Partial Halo	M2.6 AR3767 M1.7 AR3768	18W 08S	747 km/s	31/0300 -6/+12 hrs	As above

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Radio Blackouts - X-Ray Flares:

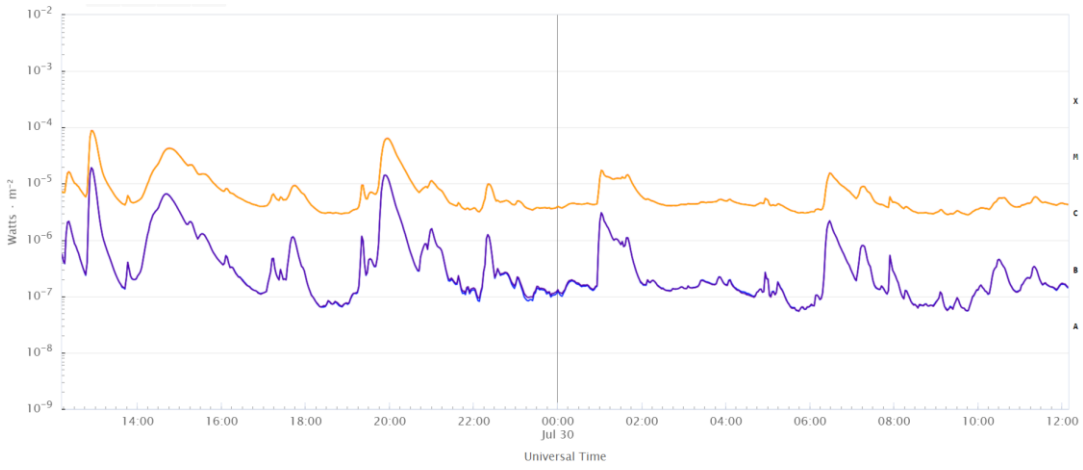
High to Moderate activity is forecast, with M-class flares expected and a chance of further isolated X-class flares.

There are eleven regions, with a number showing a notable flare potential On the southwest disc, AR3768 has been a relatively active spot and has recently seen some slow penumbra growth, alongside the persistence of a delta spot within its intermediates. Across the south-centre disc, a complex cluster of sunspots, AR3764, AR3766, AR3765 and AR3767 also continue to be a likely source of occasional M-class flares. The persistence of delta spots within AR3766 and AR3765, alongside the likely interaction of the spots due to their proximity, also brings a chance of stronger flares. AR3770 in the north-centre disc also has a small, but strong delta spot, and this region also has the potential for notable flare activity. The newly numbered AR3772 is currently difficult to assess due to its oblique viewing angle, but is bright on SDO aia-94, and has also been a source of a couple of M-flares and CMEs while on or just around the limb, with further such flares possible.

There is also a region of bright looping evident on the central eastern limb, which likely corresponds to a far-sided region that was the source of strong flares observed by solar orbiter while on the far-side. This region will rotate onto the Earth-side during the next 12-24 hours.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	90	85	80	80
Very Active	R3 to R5 X Class	No	25	25	25	25

Figure 3: SWPC X-ray flare trace showing activity over last 24 hours.



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Solar Radiation Storms - (High Energy Protons):

High energy proton flux, as observed by GOES-18 is currently is currently at background but has the potential to see small rises in response to any notable flares on the disc, with a number of moderately sized and complex sunspots moving into the western hemisphere. This bring a chance of reaching the S1 Minor Radiation Storm level.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux, as observed by GOES-16, is expected to be at background for much of the period. Recent fast wind enhancement did bring a small enhancement to Moderate at diurnal peak, however this has now been suppressed by the CME arrival late on 29 Jul. Further CME arrivals anticipated to keep the observed flux at background, but may allow for a re-enhancement once any CME influence recedes, with Moderate flux possible day 3-4 (01-02 Aug)

The associated 24 hr electron fluence is expected to remain below Active. MOSWOC REFM is currently providing a reasonable guide, but confidence in this becomes Low with any further CME arrival on 31 Jul.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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